(19) Japan Patent Office (JP)

(12) Patent Application Publication (A)

(11) Publication Number: Japanese Published Patent Application No. 2003-66908 (P2003-66908A)

(43) Date of Publication: March 5, 2003

(51) Int. Cl.^{7}	Identification Symbol	FI		Theme Code (reference)
G 09G 3/30		G 09G 3/30	K	3K007
G 09F 9/30	338	G 09F 9/30	338	5C058
	365		365Z	5C080
G 09G 3/20	611	G 09G 3/20	611E	5C094
	623		623R	

The Number of Claims: 17 OL (16 pages in total)

Request for Examination: not requested

Continued on the last page

(21) Application Number: 2001-257351 (P2001-257351)

(22) Date of Filing: August 28, 2001

(71) Applicant: 000005821
Matsushita Electric Industrial Co., Ltd.
1006, Kadoma, Kadoma City, Osaka, Japan

(72) Inventor: Hitoshi TSUGE
c/o Matsushita Electric Industrial Co., Ltd.
1006, Kadoma, Kadoma City, Osaka, Japan

(72) Inventor: Hiroshi TAKAHARA
c/o Matsushita Electric Industrial Co., Ltd.
1006, Kadoma, Kadoma City, Osaka, Japan

(74) Representatives: 100097445
Patent attorney: Fumio IWAHASHI and two others

Continued on the last page

(54) Title of the Invention: ACTIVE MATRIX TYPE DISPLAY DEVICE AND DRIVING METHOD THEREOF

(57) [Abstract]

[Problem to be Solved]

To reduce display unevenness due to dullness of a current waveform caused by a floating capacitance of a source signal line in an active matrix type display device which performs current driving.

[Solution]

In order to make an electric charge stored in a floating capacitance correspond with a display grayscale quickly, a voltage source 18 is prepared in addition to a current source 10 which controls a grayscale; the electric charge of the floating capacitance is instantly changed by the voltage source 18 at the beginning of a row selection period by using a power source switching means 19 for switching between two power sources which are inputted to a source signal line, and then, grayscale display is performed with the current source 10 to obtain desired luminance.

[Scope of Claims]

[Claim 1]

An active matrix type display device characterized by comprising:

voltage application means to apply a predetermined voltage to a source signal line;

means to supply a predetermined amount of current; and

switching means to switch between the voltage application means and the means to supply current as an input of the source signal line.

[Claim 2]

A driving method of an active matrix type display device which performs grayscale display with an amount of current which flows to a source signal line, characterized by comprising the steps of:

providing voltage application means which applies a predetermined voltage and switching means,

wherein a voltage application period with the voltage application means and a period in which grayscale display is performed with the amount of current which flows to the source signal line are provided in one horizontal scanning period by using the switching means.

[Claim 3]

The driving method of an active matrix type display device according to claim

2, characterized in that the voltage application period is 0.5 μs or more and 3 μs or less.

[Claim 4]

A driving method of an active matrix type display device which performs grayscale display with an amount of current which flows to a source signal line, in a case where there is a period during which all rows are not selected from when a first row is selected to when a second row that is different from the first row is selected, characterized by comprising the steps of:

providing voltage application means which applies a predetermined voltage and switching means; and

providing a voltage application period with the voltage application means in the period when all rows are not selected by using the switching means,

wherein grayscale display is performed with the amount of current which flows to the source signal line in accordance with, during a period when at least one row is selected, the number of grayscales which is displayed on the row thereof.

[Claim 5]

The driving method of an active matrix type display device according to claim 4, characterized in that the voltage application period is included in a period when at least one row is selected.

[Claim 6]

A driving method of an active matrix type display device which performs grayscale display with an amount of current which flows to a source signal line, characterized by comprising the steps of:

providing means which applies different number of voltages, which are greater than or equal to three and less than or equal to six in accordance with a grayscale, and switching means,

wherein a voltage application period and a period in which grayscale display is performed with the amount of current which flows to the source signal line are provided in one horizontal scanning period by using the switching means.

[Claim 7]

A driving method of an active matrix type display device which performs grayscale display with an amount of current which flows to a source signal line, characterized by comprising the steps of:

providing a period when current which is 3 times or more and 20 times or less than a predetermined current value that is determined for each grayscale is supplied in one horizontal scanning period.

[Claim 8]

A driving method of an active matrix type display device which performs grayscale display with an amount of current which flows to a source signal line, characterized by comprising the steps of:

providing means which applies a predetermined voltages and switching means; and

providing a voltage application period and a period in which grayscale display is performed with the amount of current which flows to the source signal line by using the switching means,

wherein a period when current which is 3 times or more and 20 times or less than a predetermined current value that is determined for each grayscale flows is provided during a period when grayscale display is performed with the amount of current which flows to the source signal line.

[Claim 9]

A driving method of an active matrix type display device using an organic light-emitting element which performs grayscale display with an amount of current which flows to a source signal line, characterized by comprising the steps of:

including means which applies a predetermined voltages and switching means; and

providing a voltage application period with the voltage application means and a period in which grayscale display is performed with the amount of current which flows to the source signal line in one horizontal scanning period by using the switching means,

wherein a voltage value during the voltage application period is varied with respect to the organic light-emitting element having a different light-emitting start voltage.

[Claim 10]

A driving method of an active matrix type display device which performs grayscale display with an amount of current which flows to a source signal line,

characterized by comprising the steps of:

including a plurality of oscillators, a switching circuit which selects one output of the plurality of oscillators, a divider circuit for reducing a frequency of the plurality of oscillators, voltage application means, and switching means which connects or disconnects the voltage application means and the source signal line,

wherein the switching means makes a connection period to the source signal line different due to an output frequency of the divider circuit.

[Claim 11]

A driving method of an active matrix type display device which performs grayscale display with an amount of current which flows to a source signal line, characterized by comprising the steps of:

forming voltage application means, switching means which connects or disconnects the voltage application means and the source signal line, and a circuit for one pixel display as well as a pixel for display in the display device; and

supplying an amount of current in accordance with a grayscale with the lowest current value from a node to be connected to the source signal line of the circuit,

wherein means which changes a voltage value applied by the voltage application means in accordance with an amount of voltage drop in the circuit is provided.

[Claim 12]

A driving method of an active matrix type display device, characterized by comprising the steps of:

including a period when voltage in accordance with a grayscale is applied to a source signal line and a period when current in accordance with the grayscale flows in the source signal line in one horizontal scanning period.

[Claim 13]

The driving method of an active matrix type display device according to claim 12, characterized in that the period when the voltage in accordance with the grayscale is applied to the source signal line is 1 % or more and 50 % or less of one horizontal scanning period.

[Claim 14]

A handheld terminal comprising: the display device according to claim 1; an

antenna; and a key input circuit.

[Claim 15]

A semiconductor circuit for driving, characterized in that the driving method according to claim 2 or 12 is performed.

[Claim 16]

An active matrix type display device characterized in that the semiconductor circuit according to claim 15 is formed of a low temperature polysilicon.

[Claim 17]

A television characterized by comprising: the display device according to claim 1; a light-emitting portion using an organic light-emitting element; a video signal processing circuit; and applied voltage control means.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a display device which performs grayscale display with the amount of current, such as an organic light-emitting element.

[0002]

[Conventional Art]

Since an organic light-emitting element is a self-luminous element, a backlight needed for a liquid crystal display device is unnecessary, and the organic light-emitting element is expected as a next-generation display device in terms of advantages such as a wide viewing angle.

[0003]

[Problems to be Solved by the Invention]

Like an organic light-emitting light element, the light-emission intensity of an element and an electric field applied to the element do not have a proportional relationship, and the light-emission intensity of the element and the current density which is supplied to the element have a proportional relationship; therefore, the variation of the light-emission intensity can be reduced with respect to the variation of the thickness of the element and the variation of an input signal value when grayscale display is performed with current control.

[0004]

FIG. 16 shows an example of an active matrix type display device using a switching element having a semiconductor layer. Each pixel includes, as shown by a reference numeral 79, a plurality of switching elements 73, a storage capacitor 74, and an organic light-emitting element 72.

[0005]

As for the switching elements 73, switching elements 73a and 73b are turned on, and a switching element 73d is turned off with an output from a gate driver 70 in a row selection period (a period A) of one frame. On the other hand, the switching element 73d is turned on, and the switching elements 73a and 73b are turned off in a non-selection period (a period B).

[0006]

With this operation in the period A, the amount of current which flows to a switching element 73c is determined in accordance with a current value outputted from a source driver 71, and a gate voltage is determined by the relationship between a source-drain current and a gate voltage of the switching element 73c, so that an electric charge corresponding to the gate voltage is stored in the storage capacitor 74. In the period B, the gate voltage of the switching element 73c is set in accordance with the amount of an electric charge stored in the period A; therefore, the same current as the current which flows to the switching element 73c in the period A also flows to the switching element 73c in the period B, and the organic light-emitting element 72 emits light through the switching element 73d. In accordance with the amount of current of a source signal line, the amount of an electric charge of the storage capacitor 74 is changed, and the light-emission intensity of the organic light-emitting element 72 is changed.

[0007]

As a display pattern, it was found that the luminance of a pixel in a non-lighting period varied between the case where current flowed to a certain source signal line in the order of lighting and non-lighting and the case where current flowed to a certain source signal line in the order of non-lighting and non-lighting. In the case where current flowed in the order of lighting and non-lighting, a non-lighting pixel emitted light at a luminance of about 0.5 where luminance in a lighting period was set at 1 and luminance in a non-lighting period was set at 0. In addition, it was found that

the luminance of the non-lighting pixel gradually decreased from 0.5 in the case where a non-lighting signal was continuously supplied in the rest of the same frame period after a lighting signal was supplied once, and that the luminance became 0 from the sixth or seventh row where the frame frequency was 60 Hz and the number of display rows was 220.

[0008]

On the other hand, in the case where a lighting signal was supplied after non-lighting, the lighting luminance was 0.8 at first; however, display was able to be performed at a luminance of 1 from the third row.

[0009]

The above description shows that, although the output of the source driver changes a current value in accordance with a display pixel, a current waveform supplied to each pixel becomes dull due to wiring resistance and a floating capacitance of the source signal line and a desired current value is not stored in each pixel as an electric charge of the storage capacitor 74. That is, it was found that the capability of writing a desired current value was poor. In particular, it was found that, compared with the change from a small current value to a large current value, the time to change from a large current value to a small current value took about twice as long.

[0010]

It was confirmed that the above-described problem was reduced by decreasing the frame frequency, taking a long writing time for each row, and reducing an effect of waveform dullness.

[0011]

When the frame frequency is decreased, in the case where off characteristics of the switching elements 73 are bad, the amount of the electric charge of the storage capacitor 74 is changed due to leakage of the switching elements 73, and the amount of current of the organic light-emitting element 72 is changed; accordingly, a flicker occurs.

[0012]

Therefore, in order to obtain display without a flicker, it is necessary that dullness of a current waveform be reduced and a desired current value flow in a selection period regardless of a current value flowing to a pixel which is displayed just

before that.

[0013]

[Means for Solving the Problem]

In order to solve the above-described problem, an active matrix type display device of the present invention is provided with means to apply a predetermined voltage to a source signal line; means to supply a predetermined amount of current; and switching means to switch between the voltage application means and the means to supply current to the source signal line, in which the amount of current which flows to the source signal line is changed fast due to a change of a video signal.

[0014]

[Embodiment]

Hereinafter, embodiment modes of the present invention will be described with reference to drawings.

[0015] (Embodiment Mode 1)

FIG. 1 is a diagram showing a driver circuit of an organic light-emitting element for two pixels connected to one source signal line in Embodiment Mode 1 of the present invention.

[0016]

A characteristic of the present invention is that the current source 10 which supplies a desired current in accordance with a display grayscale and the voltage source 18 for applying a predetermined voltage are provided and that a power source which is inputted to the source signal line can be switched by the power source switching means 19.

[0017]

The size of each pixel of a display portion of a cellular phone, a monitor, and the like is about 100 μm wide and about 250 μm long, and a current value required for the source signal line for obtaining a luminance of 100 candela/square meter varies in accordance with a display color and external quantum efficiency; however, the current value is about 1 μA.

[0018]

In order to supply 1 μA to an EL element 16, the power source switching

means 19 selects the current source 10 and a current value which is supplied to the current source 10 is set at 1 μA on a source driver side.

[0019]

In a selected row, a signal by which a switching element 17 is turned on is applied to a gate signal line 1 denoted by a reference numeral 12, and an off signal is applied to a gate signal line 2 denoted by a reference numeral 13. On the other hand, in a non-selected row, an off signal is applied to the gate signal line 1 denoted by the reference numeral 12, and an on signal is applied to the gate signal line 2 denoted by the reference numeral 13.

[0020]

Accordingly, in the selected row (in this example, the first row), current of the source signal line 11 flows into the pixel through switching elements 17b and 17c. A current path in the pixel is just connected to an EL power source line 15a through a switching element 17a; therefore, a current of 1 μA also flows to the switching element 17a, and an electric charge for the amount of gate voltage at this time is stored in a storage capacitor 14a. In the non-selection period, a switching element 17d is turned on, and the switching elements 17b and 17c are turned off; therefore, current which flows to the switching element 17a is defined based on the electric charge stored in the storage capacitor 14a in the selection period, and a current of 1 μA flows to an EL element 16a.

[0021]

For this reason, in order to supply a desired current value (for example, 1 μA) to the EL element 16a, in the selection period, it is necessary to store an electric charge in the storage capacitor 14a so as to apply a gate voltage by which the switching element 17a supplies a desired current value.

[0022]

However, when there is a floating capacitance 20 in the source signal line 11, dullness of a waveform, which is determined by time constant of a wiring resistance and the floating capacitance 20 of the source signal line 11, is observed. In the case where grayscale display is performed with the current value, the dullness of the waveform varies depending on the current value which is supplied to the source signal line, and

rising and falling take time as the current value is small. For example, when the wiring capacitance was 100 pF and the wiring resistance was 500 ohm, time required to change a current value of the source signal line and a current value of a node 1001 from 0.24 μA to 40 nA was 300 microseconds and time required to change from 40 nA to 0.24 μA was 250 microseconds at the time when a current value of the current source 10 was changed.

[0023]

Since the movement of an electric charge per unit time in a low current region is small, it is difficult to charge and discharge an electric charge accumulated in the floating capacitance 20. For example, as shown in FIG. 17, it was found that, when an on period of the gate signal line 1 denoted by the reference numeral 12 was changed between 64 microseconds and 256 microseconds, almost the same output current was obtained with respect to an input current in the case of 256 microseconds, while the output current varied with respect to an input, mainly at low current (0.7 μA), in the case of 64 microseconds.

[0024]

Therefore, in a conventional method of grayscale display with current, the minimum time of one horizontal scanning period needs 300 microseconds. This needs to drive one frame at about 10 Hz in the case where the number of scanning lines is 220, like a cellular phone. In accordance with off characteristics of the switching element 17, the amount of an electric charge of the storage capacitor 14 is changed, and a flicker occurs due to the change of current which flows to the EL element 16.

[0025]

In addition, in the case where a voltage value is applied to the source signal line, since decision is made only with the time constant of the wiring resistance and the floating capacitance 20 of the source signal line regardless of the voltage value, a voltage value of the node 1001 is about 1 microsecond and is fast, compared with the time when a voltage value corresponding to a current value of the node 1001 is determined by the current source 10.

[0026]

Therefore, in order to shorten one horizontal scanning period, in the present

invention, a method to use that time of change from low current (black display) to high current (white display) is faster than time of change from high current (white display) to low current (black display) in the change of a current waveform was thought.

[0027]

As shown in FIG. 2(a), at the beginning of one horizontal scanning period, the power source switching means 19 is switched to a voltage source 18 side, and voltage of the source signal line 11 is set the same voltage as the state in which a current value of a black signal is supplied by using the voltage source 18 (a discharge voltage application period 24). Next, the power source switching means 19 is switched to a current source 10 side, and a desired current value in accordance with a video signal is supplied to the source signal line 11 by the current source 10 (a video signal current application period 25).

[0028]

FIG. 3 shows the dependence on the voltage application period of the output current with respect to an input current. When the input current is 1 μA, the output is almost 1 μA regardless of voltage application time. In the case where the input current is as small as 40 nA (supposed to be black display), the output is 0.65 μA when there is no voltage application period, the output is 0.38 μA when the voltage application period is 4 microseconds or more, and the output is not affected any more when the voltage application period is 4 microseconds or more. Accordingly, since a current display period is desired to be lengthened, the source signal line has a voltage value of black as long as the discharge voltage application period 24 has a maximum of 4 microseconds, and desirably from 0.5 microsecond to 3 microseconds. In addition, as for the video signal current application period 25, time to be a desired current from black display is also about 250 microseconds in the case of changing from black display to white display which takes the most time, and is about 270 microseconds in the case of halftone display, which is shorter than the time of change from white display to black display. Therefore, one horizontal scanning period can be about 270 microseconds maximum and was able to be shortened to 90 % of time compared with conventional 300 microseconds; accordingly, a low flicker display was able to be made.

[0029]

Furthermore, during the discharge voltage application period 24, by applying a source voltage so as to provide a luminance of 0.01 candela/square meter or less, luminance at the time of black display can be reduced, and an image that deepens black can be displayed. For example, voltage close to voltage which is supplied from the EL power source line 15 may be applied to the source signal line 11. During current driving, it is necessary to supply a minute current (several nA) to apply voltage which is close to an EL power source voltage to the source signal line 11, and voltage regulation of the source signal line with a current of several nA is difficult because it takes from several hundred microseconds to 1 millisecond as described above.

[0030]

In this way, voltage insertion in the present invention is effective for performing black display in a short time.

[0031]

Note that in the case where there is a period in which all rows are not selected when a scan row changes from a certain row (N-th row: N is a natural number) to the next row (M-th row: M is a natural number but not N) as shown in FIG. 2(b), at the time when a gate control signal is active (in the state where all the rows are not selected), a voltage value to be black display may be applied and a video signal current corresponding to a selected row may be inputted during a selection period; or as shown in FIG. 2(c), a black voltage application period may be spread over the state where all the rows are not selected and part of a one-row selection period.

[0032]

That is, since an aim of black voltage application is to charge an electric charge up to a black state in the floating capacitance 20 of the source signal line 11, a pixel transistor connected to the source signal line 11 may be either turned on or off.

[0033]

In order to lengthen current writing time required for original grayscale display, a voltage application period preferably includes a period in which all rows are not selected in the case where there is the period in which all the rows are not selected.

[0034]

In addition, during the voltage application period, voltage applied to the source signal line 11 is not necessarily voltage to display black; however, because of the

current source 10, black display takes more time to change to a voltage value corresponding to a predetermined current value than that of white display. Therefore, it is desirable that a voltage value of the voltage source 18 be a value closer to a black-signal voltage value than an intermediate value between a white signal voltage and a black signal voltage.

[0035] (Embodiment Mode 2)

In Embodiment Mode 1, by providing the discharge voltage application period 24 and applying voltage to display a black signal, the source signal line was able to be easily changed to current to display black.

[0036]

Accordingly, since the amount of voltage change in grayscales of black and close to black was decreased, display was able to be performed with one horizontal scanning period of 200 microseconds to 230 microseconds. In addition, since the amount of current was the maximum amount at the time of white display, the discharge rate of an electric charge of the floating capacitance 20 existing in the source signal line 11 was fast, and even the amount of change was large; however, display was able to be performed with one horizontal scanning period of about 180 microseconds. On the other hand, the amount of current of the grayscale close to black rather than a grayscale close to intermediate between white and black is half or less than that at the time of white display. Therefore, the discharge rate of the electric charge of the floating capacitance 20 is half, so that one horizontal period is about 250 microseconds, which is the longest.

[0037]

So, it was thought that, during the discharge voltage application period 24, different voltages in several stages were applied in accordance with a grayscale of a video signal which was to be displayed next without applying voltage to display a black signal.

[0038]

FIG. 4 shows an inner block of the source driver portion 71 of a display device of the present invention to realize this. A grayscale of an input video signal is detected with a grayscale data detection means 52, and the amount of current which flows to a current source for a source signal 53 is controlled with a detection result; and at the

same time, one of a plurality of voltage sources 54a to 54c is selected. In addition, the output of a voltage application period control portion 51 is changed in accordance with a horizontal synchronization signal, so that a voltage application period and a current application period are controlled.

[0039]

In FIG. 1, in the case where a signal is written from the source signal line 11 to the pixel, the switching elements 17b and 17c are turned on, the switching element 17d is turned off, and an equivalent circuit for one pixel at this time is shown in FIG. 5(a).

[0040]

In the case where a predetermined current *I* flows to a source signal line 124 with a current source 125, the amount of current that is the current *I* also flows to a transistor 121. As seen in FIG. 5(a), since a source or a drain of the transistor 121 and a gate thereof have the same potential, a potential of the source signal line 124 is changed depending on a current value in the case where a gate voltage and a drain current of the transistor 121 have a relationship as shown in FIG. 5(b).

[0041]

For example, in the case where current which flows to the source signal line 124 is changed from $I1$ to $I2$, the potential of the source signal line 124 is changed from (Vdd - V1) to (Vdd - V2). The case of change from $I1$ to $I3$ is also similar to this.

[0042]

As shown in FIG. 5(c), time required for changing a current value differs in accordance with a current value after change. The change from $I1$ to $I2$ takes (t4 - t1) as shown by a solid line 126, and the change from $I1$ to $I3$ takes (t3 – t1) as shown by a dotted line 127. Accordingly, it is found that change takes time as a current value is small, because charging/discharging a floating capacitance 123 of the source signal line 124 takes time when a low current is used.

[0043]

So, considering that change takes time in a low current region (a grayscale close to black), by applying different voltage values to each display grayscale or each plurality of display grayscales, the amount of change was reduced, and writing time was made to be shortened.

[0044]

For example, in the case of 16-grayscale display, voltages corresponding to grayscales of 1, 2, and 4 are prepared; the voltage corresponding to the grayscale of 1 is applied in the voltage application period in the case of the grayscale of 1; the voltage corresponding to the grayscale of 2 is applied in the case of the grayscales of 2 and 3; and the voltage corresponding to the grayscale of 4 is applied in the case of the grayscale of 4 or more. Accordingly, time required for writing, particularly, writing time in the low current region which takes time can be shortened, and one horizontal scanning period is 220 microseconds at earliest regardless of a display grayscale.

[0045]

Similarly in the case of another grayscale, each voltage value applied by the plurality of voltage sources in FIG. 4 may be set to a voltage value which is closer to the low current region than a voltage value which is obtained by dividing the voltage between the maximum voltage value and the minimum voltage value which are required for grayscale expression with the number of voltage sources 54 at even intervals.

[0046]

Further, although the number of power sources to be prepared depends on a voltage amplitude that the source signal line 124 has, it is desirably about 5 at most in view of the increase in circuit scale of the source driver and improvement in image quality due to increase in number of power sources.

[0047] (Embodiment Mode 3)

As a display device which performs grayscale control with current, an organic light-emitting element is given. One of methods to realize a multi-color display device using an organic light-emitting element is a method in which a red light-emitting element, a green light-emitting element, and a blue light-emitting element are arranged for realizing multi-color.

[0048]

Since luminous efficiency, mobility of carriers in an organic layer, and an energy difference from an electrode to the organic layer differ for each emission color, the relationships between current and luminance, between voltage and luminance, and between current and voltage differ for each emission color. For example, as shown in FIG. 18(a), luminance differs with respect to the same voltage value, and as a result, a light-emission start voltage also takes a different value in such a way that an element G

is V1 and an element R is V2. In addition, as shown in FIG. 18(b), a light-emission start current also differs.

[0049]

In Embodiment Mode 1, a voltage value during a voltage application period was one type. When a voltage application is performed with the same voltage value to a display device formed of two types of elements G and R shown in FIG. 18 in this embodiment mode, in the case where voltage corresponding to $J2$ which is a current value of black display of the element R is applied to all source signal lines, a potential is not to be a potential corresponding to black display in the source signal line connected to the element G, and it is required to change the potential of the source signal line with respect to black display which takes the most time. On the other hand, in the case where voltage corresponding to $J1$ is applied to the source signal line, a voltage value higher than a voltage value of black display is applied with respect to the element R, and there is a problem in that a voltage amplitude of a source signal is increased, compared with the case where there is no voltage application period.

[0050]

So, in the case where an element which has a different light-emission start-current value depending on the source signal line is formed, a different voltage source may be provided for at least each source signal line for which an element that has a different light-emission start-current value is formed so that a black signal voltage can be adjusted. In the case of the display device formed of the elements R and G in FIG. 18, two voltage sources 54 in the structure of FIG. 6 are prepared, so that a different voltage source is provided for each of a source signal line along which the elements R are arranged and a source signal line along which the elements G are arranged.

[0051]

In addition, in order to shorten writing time further, a plurality of voltage sources may be further prepared with respect to each signal line as is in Embodiment Mode 2 so that the application voltage value is changed in accordance with a grayscale.

[0052] (Embodiment Mode 4)

The faster the frame frequency becomes, the shorter one horizontal scanning period becomes; therefore, in the case where the frequency is fast, each voltage value of the plurality of voltage sources implemented in Embodiment Mode 2 is prepared

focusing on a voltage value corresponding to close to black display which takes time for writing. On the other hand, when the frame frequency is slow, since time required for a voltage change can be taken long, the way of taking a voltage value may be shifted to a white display side. Accordingly, luminance at the time of white display can be improved, which leads to the improvement in contrast.

[0053]

In a display device which needs a low power drive, such as a handheld terminal, full screen is displayed at the time of operation of a button 184 shown in FIG. 14; however, in the case where the button 184 is not operated for a long time such as standby time, a partial display mode which performs only partial display is used to reduce power consumption in some cases.

[0054]

At the time of the partial display mode, since the number of display lines is decreased, the frame frequency can also be decreased and a circuit can be operated by using an oscillation frequency which differs from that at the time of full screen display.

[0055]

FIG. 7 shows a block diagram of a source driver portion and a controller of a display device corresponding to a plurality of frame frequencies, provided with a plurality of oscillators, a switching circuit, and a divider circuit. Grayscale display is performed by outputting data read from a memory 86 to a source signal line through a selector 88 with a grayscale control portion 87 which controls or selects a current source 90. A voltage value of application voltage is determined by a voltage control means 85 and a voltage generation portion 89; further, the voltage control means 85 can receive the output of an oscillation frequency detection means 83 and can change the voltage value with the frequency. Therefore, depending on a difference in the frame frequency, each voltage value of the plurality of voltage sources during the voltage application period can be changed, so that optimum grayscale display can be performed.

[0056]

In addition to the handheld terminal, for example, in the case where the display device is used as a television, the frame rate varies when a different video signal transmission mode is used. In the case of forming a display device corresponding to both the modes, the transmission mode is detected by a video signal processing circuit

194, and a combination of voltage values of a plurality of voltage sources is changed, so that optimum grayscale display can be performed in a television shown in FIG. 8.

[0057] (Embodiment Mode 5)

As the black voltage application performed in Embodiment Mode 1, by using current versus voltage characteristics of the transistor 17a in FIG. 1, the voltage value corresponding to the current value at the time of black display was applied. However, since a voltage value corresponding to the same current has a possibility to be changed between lots or depending on the position of a substrate, an input voltage value is required to be adjusted for each display device in order to apply an optimum black voltage value.

[0058]

Adjustment for each display device makes a manufacturing process complex, which is not desirable. So, considering that variation of a voltage value is smaller between pixels of the display device than that between lots, it was thought that at least one transistor for test is formed in the display device, and a gate voltage of a transistor required when current at the time of black display flows to the transistor is detected, and a voltage value corresponding to the detected voltage value is applied to a source signal line. A circuit structure thereof is shown in FIG. 9.

[0059]

A current value which shows a black signal is supplied to a source signal line 100. At this time, the same current value is supplied to a drain of a transistor 98. At this time, a potential difference between a node 99 and an EL power source line 96 is detected by a voltage detection means 91, and the detection result is inputted to a voltage generation means 92, so that a voltage value corresponding to the voltage source 18 of FIG. 1 is changed. A voltage application period and a current period are controlled by a selector 93.

[0060]

By this method, since voltage of black display can always be applied even when current versus voltage characteristics of a driver transistor vary between lots, black floating due to variation of fabrication of a transistor can be prevented.

[0061]

Note that, when current values corresponding to various grayscales are

supplied to the source signal line 100, voltage at this time can be detected by the voltage detection means 91 and applied to the source signal line by using the voltage generation means 92 and the selector 93. Therefore, the present invention is not necessarily limited to the time when a black signal is applied, and the present invention can be applied to the case where voltage corresponding to a certain grayscale is applied in general.

[0062] (Embodiment Mode 6)

The change of a current value of a source signal becomes faster as a current value after change increases. As shown in FIG. 5(c), in the case of change from the current $I1$ to $I2$ or $I3$, the change to $I3$ which has a larger current value can be changed in a shorter time. This is because, since a current value is changed by extracting or storing an electric charge of the floating capacitance 123 of the source signal line with the current source 125, the current value can be changed faster in a high current region through which a lot of electric charges can flow.

[0063]

Accordingly, by using that the rising time of a waveform shortens as a lot of current flows, a current value which is 3 times or more and 10 times or less as large as a predetermined current value corresponding to a display grayscale is supplied from the start to a certain period 133 in one horizontal scanning period shown in FIG. 10. During a period 135 after that, a predetermined current value is supplied. Accordingly, compared with the conventional case where the current value changes as shown by a reference numeral 131, rising can be made fast as shown by a reference numeral 132. Therefore, writing time can be shortened, one horizontal scanning period 134 can be shortened, and writing can be performed in 230 microseconds. This method can realize a source driver with a small circuit scale because a voltage source is unnecessary unlike Embodiment Modes 1 to 5, and a voltage generation portion and a selector are unnecessary.

[0064]

Although the writing speed can be faster when current is increased by 3 to 10 times as large at the time of black display, luminance increases when current rises; therefore, in the case where the current value is increased by 10 times as large, there is a case where black floating occurs. In addition, in the case where the source current

value decreases more in the next scanning period than the source current value in one scanning period, since luminance increases, there is a possibility that a problem occurs in that contrast decreases even when writing speed becomes fast.

[0065]

So, as shown in FIG. 11, a black-signal voltage insertion period 144 is provided at the beginning of one horizontal scanning period similarly to Embodiment Modes 1 to 5, and then, a period 145 in which a current value of 3 times or more and 10 times or less as large is supplied and a period 146 in which a current value corresponding to a grayscale is supplied are provided.

[0066]

When the current value changes from small to large, with the period 145 in which a current value of 3 times or more and 10 times or less as large is supplied, change can be made fast as shown by a reference numeral 142 compared with a conventional rising 141.

[0067]

When the current value changes from large to small, since change to a black state can be made with the black signal voltage insertion period 144 at the moment (at least within 4 microseconds), falling can also be changed fast.

[0068]

A circuit structure for realizing such a waveform is shown in FIG. 6. Realization can be made with almost the same structure as that in Embodiment Mode 1, and by changing the output of the grayscale data detection means 52 in a horizontal scanning period, a period with 3 times or more and 10 times or less as large as a predetermined current and a period in which a predetermined current value is supplied can be made. Accordingly, one horizontal scanning period can be scanned in 150 microseconds.

[0069] (Embodiment Mode 7)

With Embodiment Mode 6, when a display device having 220 scanning lines for example was used, operation was able to be made with a frame frequency of 30 Hz. Therefore, display with small flickering was possible. However, in the case of being applied to one with a frame frequency of 60 Hz, like a television, increase in luminance at the time of black display and decrease in luminance at the time of white display due

to writing deficiency are generated.

[0070]

Furthermore, as a method for making writing time fast, methods shown in FIG. 12 and FIG. 13 were thought. As shown in FIG. 13, a voltage value corresponding to a grayscale is applied to a source signal line at the beginning of one horizontal scanning period (grayscale display 114 corresponding to a voltage value). Since the speed of a voltage change at this time is determined by a time constant determined by a wiring resistance and a floating capacitance of the source signal line, it is 2 microseconds or less. In the pixel structure of FIG. 1 as it is, when current is made to flow to the EL element 16, in the case where the relationship between a gate voltage and a drain current of the switching element 17a or 17e is changed for each pixel, the current value changes by the same amount of change, and display unevenness occurs due to the change of luminance of the EL element 16. So, in the rest of a period 115, by supplying current in accordance with a current value to the source signal line, the gate voltage of the switching element 17a or 17e is changed so that a predetermined drain current flows. In this manner, variation of current voltage characteristics of a transistor is corrected, and a display device with no display unevenness is realized.

[0071]

A circuit structure at this time is shown in FIG. 12. With the grayscale data detection means 52 which is provided in each source signal line, the current source 53 and a voltage source 104 are controlled, and the amount of current or a voltage value is changed depending on each grayscale. Accordingly, in the periods 114 and 115, voltage and a current value are changed depending on each display grayscale, and furthermore, a switching means 106 which determines whether the current source 53 or the voltage source 104 is connected to the source signal line is controlled by a voltage-current switching control portion 51 controlled by a horizontal synchronization signal; therefore, lengths of the period 114 and the period 115 can vary in a horizontal scanning period 113.

[0072]

Also in writing time, the amount of which current changes during a period when grayscale display is performed in accordance with current lies within the range of variation of current voltage characteristics of the transistor at most; therefore, it takes

about 50 microseconds at most.

[0073]

The voltage application period required may be 3 microseconds at most, and the current writing time takes about 20 microseconds. Therefore, in the case of 220 scanning lines, driving was possible at 60 Hz, so that flickerless driving was able to be realized.

[0074]

Therefore, in consideration of a margin, the voltage application period is desired to be 1 % or more and 50 % or less of one horizontal scanning period with the frame frequency.

[0075]

FIG. 14 shows one in which a demodulation device, an antenna 181, and a button 184 are attached to a display portion 182 using at least one mode of the modes of the present invention to form a handheld terminal with a chassis 183.

[0076]

FIG. 8 shows one in which a video signal input 196 and the video signal processing circuit 194 are attached to a display device 191 using at least one mode of the modes of the present invention to form a television with a chassis 197.

[0077]

In addition, in the modes of the present invention, the source driver 71 and the gate driver 70 in FIG. 16 may be formed over a glass substrate of a display device by using a low temperature polysilicon. Alternatively, the source driver 71 and the gate driver 70 may be formed as a semiconductor circuit and attached to a display panel. Still alternatively, a method may be used in which one of the drivers is formed over a glass substrate of a display device with a low temperature polysilicon and the other is formed as a semiconductor circuit to be combined with a display panel.

[0078]

In this embodiment mode, as a switching element, description is made using a P-channel switching element as an example; however, it can be similarly realized with an N-channel switching element or a combination of them. For example, when an N-channel switching element is used for a voltage value applied to the gate signal line 1 denoted by the reference numeral 12 and the gate signal line 2 denoted by the reference

numeral 13, the case of the pixel structure shown in FIG. 1 can be similarly realized in terms of a logic level, in such a way that an inverted signal of a signal of a P-channel switching element may be inputted, a direction in which current flows is reversed as for the current source 10, and voltage supplied from the EL power source line 15 is lowered compared with a terminal voltage opposite to the power switching means 19 of the current source 10. That is, except only that a relationship between a current direction and a potential is inverted, a purpose such that charge and discharge of an electric charge of the floating capacitance 20 existing in the source signal line 11 are performed fast is the same.

[0079]

In addition, description is made using the pixel structure of a dynamic current copier; however, the present invention can be similarly implemented in a pixel having a current mirror structure as shown in FIG. 15. Even in the case of a current mirror structure, a switching element 177d is turned on and a switching element 177b is turned off at the time of row selection, operation that current corresponding to a grayscale is supplied is performed with a current source 170, through an EL power source line 175, switching elements 177a and 177d, and a source signal line 171. Therefore, in the case where a floating capacitance exists in the source signal line 171, a problem in that charge and discharge of an electric charge stored in the floating capacitance is difficult to be performed in a low current region at the time when a current value of the current source 170 is changed is the same.

[0080]

In addition, it can be implemented by providing a power source switching means 179 in the source signal line 171 and by switching between the current source 170 and a voltage source 178.

[0081]

Therefore, with the implementation of the present invention, an effect such that writing speed becomes faster can be obtained.

[0082]

[Effect of the Invention]

As describe above, the present invention can shorten one horizontal scanning period and realize flickerless driving by including switching means in a source signal

line, by providing a voltage application period and a current application period in one horizontal scanning period, and by changing an electric charge stored in a floating capacitance existing in the source signal line to the amount of an electric charge corresponding to a predetermined grayscale quickly.

[0083]

In addition, a period in which a current value of 3 times or more and 10 times or less as large with respect to a current value corresponding to a display grayscale of one horizontal scanning period is supplied can be provided, and time required for a change of an electric charge stored in a floating capacitance existing in a source signal line can be shortened; therefore, one horizontal scanning period can be shortened and flickerless driving can be realized.

[Brief Description of the Drawings]

[FIG. 1] A diagram showing a pixel, a source signal line, and a power source according to Embodiment Mode 1 of the present invention.

[FIG. 2] A diagram showing timing of a voltage application period and a current application period in a horizontal scanning period.

[FIG. 3] A diagram showing dependency on a voltage application period of an output current with respect to the time of white display and the time of black display.

[FIG. 4] A diagram showing a relationship among a source driver portion, a power source portion, and a source signal line in Embodiment Mode 3 of the present invention.

[FIG. 5] A diagram showing an equivalent circuit, current voltage characteristics of a transistor in a pixel, and a waveform of a source signal line at the time of current writing from the source signal line to a certain pixel.

[FIG. 6] A diagram showing a structure of a source driver portion in Embodiment Modes 3 and 6 of the present invention.

[FIG. 7] A block diagram of a controller and a source driver portion in Embodiment Mode 4 of the present invention.

[FIG. 8] A diagram showing a television incorporating a display device in an embodiment mode of the present invention.

[FIG. 9] A block diagram for generating voltage corresponding to current of a source signal line in Embodiment Mode 5 of the present invention.

[FIG. 10] A diagram showing a current waveform flowing to a source signal line in

Embodiment Mode 6 of the present invention.

[FIG. 11] A diagram showing a current waveform flowing to a source signal line at the time of rising and at the time of falling in Embodiment Mode 6 of the present invention, compared with a conventional example.

[FIG. 12] A diagram showing a block diagram of a source driver and a structure of a pixel portion in Embodiment Mode 7 of the present invention.

[FIG. 13] A timing chart in Embodiment Mode 7 of the present invention.

[FIG. 14] A diagram of a handheld terminal incorporating a display device in an embodiment mode of the present invention.

[FIG. 15] A diagram showing an embodiment mode of the present invention in the case where a pixel has a current mirror structure.

[FIG. 16] A diagram showing a structure of a conventional display device.

[FIG. 17] A diagram showing a relationship between an input current and an output current in the case where scanning time of a gate signal line is changed.

[FIG. 18] A diagram showing differences in voltage-luminous characteristics and current density-luminous characteristics of an organic light-emitting element due to a difference in display color.

[Description of the Numerals]

10: current source

11: source signal line

12: gate signal line 1

13: gate signal line 2

14: storage capacitor

15: EL power source line

16: EL element

17: switching element

18: voltage source

19: power source switching means

20: floating capacitance

Continued from the front page

(51) Int. Cl.^{7} Identification Symbol FI Theme Code (reference)

G 09G	3/20	641	G 09G	3/20	641D
H 04N	5/66		H 04N	5/66	B
H 05B	33/14		H 05B	33/14	A

(72) Inventor: Katsumi ADACHI
c/o Matsushita Electric Industrial Co., Ltd.
1006, Kadoma, Kadoma City, Osaka, Japan

F term (reference)	3K007	AB00	AB04	BA06	CA01	CB01
		DA00	DB03	EB00	FA01	FA03
		GA04				
	5C058	AA05	BA06	BB25		
	5C080	AA06	BB05	DD06	EE29	FF11
		JJ02	JJ03	JJ04		
	5C094	AA03	AA07	AA13	AA43	AA53
		BA03	BA27	CA19	CA25	DA13
		DB01	DB04	EA04	EA07	FB01
		FB12	FB14	FB15	FB20	GA10
		GB10	JA01			